ANIMATION EFFECTS ON STUDENT LEARNING:
THE IMPACT OF ANIMATED GRAPHICS ON STUDENT RECALL

By

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This study investigated the effectiveness of simultaneously and contiguously presented animated graphics on college student recall of information contained in a multimedia instructional presentation. The investigator used quantitative methods to analyze participants' responses in the experiment. In this study, statistical analysis methods of the independent t-test and the analysis of variance were used to assess the research questions.

The main experiment consisted of a pretest, a PowerPoint presentation, and a posttest. This experiment utilized sixty-three participants in three groups. The control group viewed the presentation without the experimental treatments. The simultaneous group was provided with animated graphics presented simultaneously with the text, and the contiguous group was provided with animated graphics presented contiguously with the text.

This study suggests that use of animation in an electronic presentation may help students recall better the information contained in the presentation. In addition, a continuous display of animated graphics may improve student recall, compared to no display of animated graphics. However, a simultaneous display of animated graphics may not positively affect student recall, compared to no display of animated graphics, even though it contains animation.

CHAPTER 1
INTRODUCTION

Visual instruction has become one of the preferred instructional methods in school settings, as visual presentations have made an impact on our society (Chen, 1993). Various visual materials for instructing and learning, including pictures, videos, and CD-ROMs, are used to augment other instructional techniques and devices at all levels of education. Moreover, when visuals are incorporated into electronic presentations, they may generate increased levels of interest to learn (Hill & Hannafin, 2001). Based upon the increasing use of visually integrated instructional materials, it is crucial for instructors to understand the impact of visual images on learning.

Prior to instruction, an instructor should determine which kind of materials and which type of presentation media would be most appropriate for delivering instructional content to students (Oliver & McLoughlin, 2001; Turner, 1988). Typically, when utilizing electronic media, instructors have a variety from which to choose, such as web sites, computer software programs, instructional videos and multimedia presentations (Hartley, 2001).

Multimedia is "a computer-based product that enhances the communication of information by combining two or more of the following elements: text, graphic art, sound, animation, video or interactivity" (Ellis, 2001, p. 110). The increasing use of multimedia software by both instructors and students has resulted from the capability of the tool to present textual, visual and auditory information (Alkazemi, 2003). Currently, multimedia presentations, such as Microsoft PowerPoint presentations, are commonly used at schools (Jonassen, 1996), and such presentations may appeal to a variety of senses.

An electronic multimedia presentation can project textual and visual information on a screen, enabling presenters to utilize various visuals such as graphics, still pictures and moving pictures for the purpose of instruction (Downing & Garmon, 2001; Sloane, 2000; Toupin, 1999). For this reason, an electronic presentation tool may be useful in instruction if the use of these visuals has a positive impact on students' learning (Holzl, 1997; Shaw, 2003).

Graphics can be defined as visuals, such as arrows, that decorate, explain or point out something. Pictures are images of objects, persons, or scenes produced by photography. Animation is the movement of visual images that are displayed on electronic media. Both graphics and pictures can be animated by computer manipulation, and animation typically refers to moving graphics and moving pictures (Klecker, Hunt, Hunt & Lackner, 2003; Oliver and McLoughlin, 2001; Turner, 1988).

A number of studies have examined the effectiveness of visuals used in accomplishing various instructional tasks. Researchers (Levin & Berry, 1980) found positive results in comprehension in an experiment that utilized still and moving pictures and several passages taken from a newspaper. In their study, participating students who read a series of newspaper stories accompanied by pictorial information performed better on a comprehension task than did students who merely read stories without the pictures, implying that pictures serve as supplemental information to textual information and enhance students' cognitive activities such as memory recall and comprehension.

Furthermore, Wiley and Voss (1999) found that providing electronic instructional materials integrated with still and moving pictures improved students' learning in historical subjects. In this experiment, the students who learned from the materials with various pictures achieved a better understanding for the given content than did the students who learned from the materials without the pictures. Lamberts, Brockdorff and Heit (2002) demonstrated that the students assisted by still and moving images that accompanied textual materials performed better in an essay task than did the students who did not receive such images. Thus, when pictorial images are added to electronic presentations, it appears that students are better able to write essays about the presentations.

However, some studies suggest that visual aids in electronic instructional materials may have had either no effect or a negative impact on students' cognitive activities. Research by Martin-Michiellot and Mendelsohn (2000) demonstrated that the use of animation with text was not consistently effective. A possible reason for this lack of effectiveness, postulated by Martin-Michiellot and Mendelsohn, was related to a presentation variable identified as contiguity. Contiguity refers to the successive, rather than simultaneous, presentation of visual information with text. If text, animation, narration and other forms of visual effects are successively presented, the presentation can be regarded as contiguous. According to Martin-Michiellot and Mendelsohn, a presentation that presents visual images and narration with text simultaneously may be less effective than the same presentation presented contiguously, because simultaneous presence of visual and auditory information may generate a cognitive overload.

In terms of contiguity, researchers (Mayer & Moreno, 2002; Moreno & Mayer, 1999; Most & Greenbank, 2000) argue that (a) whether animation has a positive impact may be partially dependent upon contiguity, and (b) whether or not the contiguity is properly applied in animation may determine student comprehension and recall capacity. If the information contained in animation and on-screen text is not contiguously presented, ineffective or inaccurate recall of presented information may occur (Mayer and Moreno, 2003). When delivering content information in a multimedia presentation, it could be beneficial for instructors to understand the effect of contiguity in the display of visual images with text, because student learning seems to be affected not only by the content of textual and visual information, but also by how it is presented (Dickey & Hendricks, 1991).

Thus, it may be valuable for researchers to find the relationship between contiguous animation effects and student recall capacity, because (a) recalling is a part of learning process, (b) most studies concerning recall have dealt only with text or still images, and (c) previous studies have, for the most part, examined visual effects only on problem-solving tasks, not on recall based upon contiguity (Andrade, Kemps, Werniers, May & Szmalec, 2002; Kintsch, 1999; Mayer & Sims, 1994; Mayer, Steinhoff, Bower & Mars,1995; Winer, Cottrell, Karefilaki & Chronister, 1996).

Statement of The Problem

Researchers have suggested that the display of animations without considering contiguity in instructional presentations could have a negative impact on student performance. Nevertheless, previous studies still (a) did not examine the effectiveness of animated graphics in relation to both contiguity and recall and (b) did not clarify that a specific relationship between a contiguous display of text and animation and a simultaneous display of text and animation in an electronic presentation (Moreno & Mayer, 1999; Most & Greenbank, 2000; Quinn & McConnell, 1996).

Animation used in a contiguous treatment in a presentation is dissimilar to animation used in a simultaneous treatment. For example, whereas a contiguous presentation displays moving pictures and graphics first, followed by text successively, a simultaneous presentation presents moving pictures and graphics and text at the same time. Studies that distinguish contiguous animation from simultaneous animation may help researchers learn more about the effectiveness of animation treatments used for various instructional purposes. As a result, studies are needed to examine how effective the display of animated graphics works based upon contiguity to determine their relative impact upon a specific learning task. This study will utilize animated graphics in order to determine the effectiveness of contiguous and simultaneous presentations on student recall. Specifically, the study will measure the impact of animated graphics (animated arrows) in an electronic presentation on college student recall of the procedures for inserting information in a web page construction activity. Specific research questions are below:

1. Do students better recall techniques used for inserting information as a component of web page development in a presentation that displays animated graphics than do students who receive the presentation without the display of animated graphics?
2. Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the simultaneous display of animated graphics than do students who receive the presentation without the display of animated graphics?
3. Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the contiguous display of animated graphics than do students who receive the presentation without the display of animated graphics?

4. Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the contiguous display of animated graphics than do students who receive the presentation with the simultaneous display of animated graphics?

Significance of The Study

This study is mainly concerned with how animated graphics, based upon contiguity, affect college student recall. The significance of this study can be seen in the following ways:

This study examines the impact of different types of display of animation used as supplements to text on student recall of presented information. Thus, it will add to the knowledge base about effective production of multimedia presentations. Specifically, this study may help instructional designers and instructors in higher education effectively create and utilize electronic presentations incorporated with animated graphics in order to increase the recall capacity of college students.

Hypotheses

As this study focuses on the effectiveness of animated graphics in a multimedia presentation, the following null hypotheses are examined.

Hypothesis 1. There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 2. There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the simultaneous display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 3. There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the contiguous display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 4. There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with contiguous display of animated graphics and viewing the presentation with simultaneous display of animated graphics.

Assumptions

The predicted results of this study are based on several assumptions listed below:

Participants have not previously been exposed to the information of the experiment materials. Participants complete the given experiment procedures to the best of their ability. Each participant has a positive attitude toward the experiment procedure.

Delimitations

The scope of this study is delimited in several ways.

The participants are restricted to the students at the University of Florida. The given content is exclusively used for the purpose of the experiment, and its scope is restricted to inserting items when creating web pages. The scope of measurement is limited to student recall in the cognitive domain.

Definitions

Cognitive load – A mental process whereby information is delivered and processed in human brain.

Contiguous presentation – A presentation displaying a stimulus such as textual information first, followed by another stimulus such as visual information when viewers see a presentation slide. It presents the information successively, not simultaneously.

Moving images – All visual images that are animated. Such moving images can be made from still images resulting from a computer manipulation.

Recall – A mental process whereby people remember given information for a certain time after receiving it.

Simultaneous presentation – A presentation displaying both two stimuli such as textual and visual information at the same time when viewers see a presentation slide. It presents the information concurrently, not separately.

Split-Attention – A mental condition whereby people pay attention to stimuli such as textual information and visual information separately from one another, even though both textual and visual information should be recognized, incorporated, and understood together.

CHAPTER 2
REVIEW OF LITERATURE

The purpose of this chapter is to provide concise summaries and analyses of the research literature related to the research questions. Specifically, descriptions of the research literature are provided in relation to images (still images; moving images; interpretation of images) and cognitive load theory (introduction to cognitive load theory; cognitive overloading; contiguity).

Images

Visual images are used to (a) draw students' attention, (b) visually communicate with students, (c) help students understand instructional materials better in relation to recall and comprehension, and (d) provide additional or repetitive information (Chen, 1993; Willis & Anderson, 2002). The visual images consist of still images (pictures, drawings and graphics) and moving images (animated graphics and pictures). Also, they are typically designed based upon diverse visual variables such as size, color, shape, balance, and arrangement (Chen, 1993).

Still Images

Researchers have examined the impact of still images on students' learning (Gerjets & Scheiter, 2003). Brunken, Plass and Leutner, (2003) reviewed twelve studies on elementary school students' learning with pictures and reported positive results in which participating students clearly showed higher levels of comprehension and recall of verbal information while they read instructional materials integrated by pictures.

Additionally, they reported that the effectiveness of moving images was similar to the effectiveness of still pictures.

Levie and Lentz (1982) examined the effectiveness of pictures and found that (a) the students who viewed still images with clearly contrasting color schemes showed stronger interest in visual materials that they used than did the students who viewed still images with less contrasting color schemes, (b) the impact of pictures on students' achievement was not consistent with all types of pictures, and (c) the pictures directly related to verbal text resulted in better learning achievement than the pictures not directly related to verbal text

Chen (1993) studied the impact of pictures on students' learning and noted that the presence of relevant still pictures directly related to the given textual information (a) helped students understand abstract concepts, (b) enabled them to better focus on basic knowledge, and (c) produced positive impact on their comprehension, but (d) did not produce beneficial effect on all types of learning. Thus, the researcher implied that merely presenting still pictures might not help students learn complex content in various instructional materials.

Moving Images

In relation to moving images, Rieber (1991) examined the effect of animation in various types of visual presentations. In this study, seventy elementary school students participated in an introductory lesson on Newton's laws of motion. The experimental procedure consisted of visual presentations (still graphics vs. animated graphics) and test interval (immediate vs. delayed). The results showed that (a) when students engaged in computer activities without instructional guidance, they preferred to spend more time with electronic materials enhanced by moving images and (b) students more successfully extracted incidental information from the presentation well incorporated with animated graphics. However, the results also indicated that animation alone did not enhance students' learning, leading Rieber to suggest that examining the effectiveness of animation with the variables of text size and word length on students' cognitive activities might be important in order for instructors to help students learn better.

Boechler, Dawson and Boechler (2002) studied the effectiveness of moving images in Internet-based learning and found both positive and negative results. In their study, the Internet-based materials integrated with moving images did facilitate students' learning, compared to the materials without moving images. For example, the materials provided with moving images helped students successfully retain information more than the materials without moving images because the moving images served as supplemental information to the given textual information. Considering the positive results, the researchers implied that (a) instruction aided by moving images in a multimedia learning environment may allow students to learn better and (b) instructional materials aided by moving images may enable students to correctly interpret the given information. However, in terms of effective information navigation, the negative results showed that the students' navigation on the Internet-based materials was not effective because their navigation caused cognitive overload due to the great amounts of information from the Internet-based materials used in the experiment, but the researchers could not clarify when the moving images caused cognitive overload. Thus, a future study may need to examine the factors causing cognitive overload when learning materials are incorporated with animation effects.

In utilizing ninety-one Finnish elementary students for phonological skill learning, Puolakanaho, Poikkeus, Ahonen, Tolvanen, and Lyytinen (2003) found that moving images enabled the students to (a) successfully follow the given instructions, (b) display an interest in learning, and (c) retain certain information more than the students provided without such moving images. In this study, even though the moving images served as animated characters in order to provide corrective feedback and interactive visual rewards (visible objects coming from invisible objects when students make correct answers), such images in the experiment allowed students to spend more time and to make fewer errors on tasks while they received the information integrated with the moving images. However, the researchers implied that the study might not find similar results if the study had utilized (a) different grade students such as high school students and college students in terms of individual difference and (b) different learning tasks such as problem-solving skills. Thus, if a study deals with both high school students and a problem-solving task, the experiment for moving images effectiveness in the study may enable researchers to discover valuable findings.

In conducting an experiment with seventy-five preservice teachers, Baylor and Ryu (2003) specifically implemented the Multiple Intelligent Mentors Instructing Collaboratively (MIMIC) learning environment. They found that moving images, as electronic instructional visual agents in the given materials, played an important role in producing strong learning interest and stimulating learning motivation, compared to the materials without such instructional visual agents. In addition, the researchers implied that (a) animated visual information might support students' information retrieval in the MIMIC learning environment and (b) utilizing animated images might be useful for students' visual communication while they actively engage in learning process. They suggested that researchers might examine the impact of other types of animated images on students' cognitive activities.

In brief, research seems to indicate that (a) use of still and moving images affects students' cognitive activities in learning, (b) still and moving images may allow students to comprehend and to retain visual and textual information effectively when such images are related to the given text for instruction such as the content of solar system assisted by pictures and illustrations of ten planets, but (c) students may misinterpret the visual information if still and moving images are too much presented with the given text, which demand lots of cognitive processing so that interpretation of images is regarded as another important factor to boost the effectiveness of visual images because visual interpretation is the process of visual recognition for cognitive understanding in learning.

Interpretation of Images

The display of images delivers the specific visual stimuli to viewers, which requires the process of interpretation. For example, animated graphics, such as arrows in an electronic presentation, could be used to stimulate students' attention and lead them to follow specific instructions (Smith, 2003). However, the visual interpretation is somewhat dependent on prior experiences of the viewers. For example, even though two viewers see the same visual information, their interpretations may not be identical to each other's (Kemp & Smellie, 1994). Similarly, the process of recognition and perception does not always enable viewers to accurately interpret visual information. In other words, even though viewers perceive visual information, each viewer is likely to interpret it differently because interpretation is based upon experiences and learned skills (Martin-Michiellot & Mendelsohn, 2000).

Salomon (1997) examined students' interpretations of objects in visual media and concluded that interpretation of visual information was dependent upon both prior experience and the ability to create mental imagery. He implied that (a) the more complex the visual information, the more likely misinterpretations would occur, (b) visual complexity might require more cognitive resources and more memory capacity, and (c) visual complexity might also generate cognitive overload upon information processing.

After examining students' interpretability on visual images, Johnson (1994) and Payne (1993) demonstrated that (a) still images such as photographs and illustrations played an important role in students' perception and interpretation abilities and (b) information integrated with photographs and illustrations better functioned to simplify complicated concepts, compared to the information without photographs and illustrations. However, Johnson implied that even though an instructor may help students understand the given instructional materials by providing instructional photographs, all instructional photographs may not generate correct interpretability. Also, Payne postulated that (a) still and moving images may confuse students' interpretations because interpretation of the information of such images is related to previous experiences and (b) different interpretations may mislead students to inappropriate comprehension. For this reason, researchers have investigated how the use of still and moving images may result in a positive impact on student learning. It is because the impact of such images on student learning is related to interpretability, memory capacity, and cognitive load in terms of cognitive processing, leading the researchers to generate cognitive load theory in instruction and learning.

Cognitive Load Theory

Introduction to Cognitive Load Theory

Lamberts et al. (2000) state that students dealing with more complex information require more active mental processing than students dealing with simple information. For instance, because the task of calculation is relatively more complex than the task of time estimating, students in the task of calculation may spend more time and use more cognitive resources than do the students in the task of time estimating, meaning that more complex cognitive processing is involved. Such a phenomenon has led instructional designers and cognitive psychologists to investigate the interaction between human cognitive processing and educational technology to establish cognitive load theory.

It is important for instructional designers to consider the relationship between short term memory (or working memory) and long term memory in the human cognitive processing when designing instructional materials. In association with that, cognitive researchers developed cognitive load theory in order to optimize intellectual performance (Sweller, 1988; Sweller, Merrienboer & Paas, 1998). Also, they examined the effects such as split-attention and contiguity effect and applied such effects to "a very wide variety of curriculum materials in many educational settings" (Sweller & Chandler, 1991, p. 354). Cognitive load theory states that when the textual and visual information is loaded correctly in the stage of information processing, effective learning may occur. However, if such information is overloaded in the stage of information processing, cognitive overloading may hinder effective learning, and the learning hindrance may be more likely to occur in an electronic learning environment than a non-electronic learning environment because electronic learning materials typically store a lot of textual and visual information.

When instructional materials are not effectively designed and presented with auditory and visual information, students may experience learning problems because narration, pictures and moving images could generate additive information in two channels of information processing. When much of textual and visual information in two channels are being used, cognitive overloading would occur so that students may fail to have accurate information processing (Hinds, 1999).

Among the instructional material design methods recommended by Sweller (1999), there are two methods to help students' information processing in relation to auditory and visual information such as narration, still images, and moving images. First, instructional designers should reduce redundant and repetitive information that may be generated by simultaneous display of visual information and/or by unnecessary auditory and visual information whenever possible in the instructional material designing. If this method is effectively applied to the instructional materials, cognitive overloading in working memory may be lessened. Second, if auditory information and visual information are presented to students, instructional designers should decide which information is more important than the other. If the auditory information is more essential than the visual information, they may try to clearly emphasize and correctly provide the auditory information in order to assure students to obtain more important information even though there is a risk to generate split-attention by the use of auditory and visual channels.

Cognitive Overloading

Even though visual images in instructional materials may be "more effective at reducing ambiguity and facilitating shared meaning" (Hinds, 1999, p. 284), it does not guarantee successful information processing. It is because the more the visual information involves in learning, the more cognitive cues are activated and intertwined, which may lead students to inappropriate cognitive overloading.

Atkinson (2002) found, by evaluating the responses from fifty-one psychology majors, that (a) the students provided with both text and visual images better performed on tests than the students without the visual images, (b) the students showed more interest in the visually enhanced materials when animation served as a pedagogical agent, such as a visual guide of communication, but (c) detected that some students were distracted in following the given instruction due to too many animated images. Analyzing the results, Atkinson implied that (a) the information in pictures might help students' cognitive processing when the visual information served as supplemental information to the textual information, (b) students might be cognitively overloaded when too much visual information is distributed across the verbal and visual working memories, (c) when the information of text with animated images produced a cognitive strain on students' information processing, the effectiveness of the animated images might not work well because the information could be unnecessarily overloaded to the given text and (d) as a result, effective design and display of still and moving images should be considered.

Mayer and Moreno (2003) demonstrated the occurrence of cognitive overloading in multimedia presentations after analyzing the results of thirty case studies at the University of California at Santa Barbara. First, the negative impact of animation occurred while the students viewed animation and on-screen text simultaneously, because the students received a lot of concurrent information so that "only some of that information can be selected for further processing in visual working memory" (p. 46). Second, when animated information, text, and narration were presented simultaneously, not contiguously, the students showed poor performance. In addition, Mayer and Moreno implied that if the high spatial learners utilize the visually well-designed materials, they may produce better learning outcome in terms of spatial ability effect, but if they use the poorly designed materials, they may experience learning difficulty. As a result, because the information of text, moving images and narration could create either positive or negative impact on student learning, solid understanding the use of moving images may help instructors enable students to learn more effectively.

However, other studies show somewhat different results on a relationship between cognitive loading and moving images (Paas, Renkl & Sweller, 2003; Sweller, Merrienboer & Paas, 1998). In the analysis, they demonstrated that the students experienced cognitive overloading and were impeded to retain certain information when provided with both complex text, still images, and moving images. In spite of the negative results, they also showed that instructional materials with animated moving images enabled them to spend more time on learning in the experiment, indicating that the given materials integrated by complex text and visual images allowed them to engage in active learning regardless of cognitive overloading, but the probability of correlation between recall task and attitude toward the given materials was not high because recall capacity was in cognitive domain whereas attitude was in affective domain.

Split-Attention

Instructional materials typically include text, graphics, and pictures. When needed, a graphic is positioned with sentences. However, if such instructional information is separately presented or positioned, split-attention may result whereby students pay attention to either the graphic or the text exclusively, requiring more mental activity in order to understand the given information (Mayer & Moreno, 2003). This is because neither the graphic nor the text alone provides sufficient information to enable understanding, and the instructional information of visual and text can only be understood after students have mentally integrated the multiple sources of information. Consequently, learning may be hindered if split-attention occurs in instructional presentation, and such split-attention is likely to occur when textual information is positioned separately from visual information where both a textual presentation and a visual presentation are necessary to convey meaning.

According to Paas, Renkl, and Sweller (2003), split-attention is often associated with instructional presentations during which students need to pay attention simultaneously to two or more sources of instruction or activities. Specifically, the researchers stated that (a) split-attention occurred when the results section and the discussion section of a research paper were separately reported to the participants, even though the given sections needed to be considered simultaneously to understand the results and their implications and (b) restructuring the experimental paper (incorporating the section of results with the section of discussion) was needed to reduce split-attention.

Contiguity

To avoid split-attention and/or cognitive overload, but still use images, instructors may need to examine how still and moving images are designed and presented in instruction. One of the variables that should be considered is contiguity, especially in relation to the presentation of moving images. Researchers have shown that making moving images effective may be dependent upon visual appearance in terms of visual literacy and contiguity in terms of display of visual information (Moreno & Mayer, 1999). In other words, if a negative impact of moving images on student learning occurs, it may result from the ineffective use of visual appearance and contiguity so that a future study needs to clarify how moving images have a negative impact on student learning.

In terms of display of a presentation, a contiguous presentation of images is different from a simultaneous presentation of images. Whereas a contiguous presentation displays images followed by text, a simultaneous presentation presents both text and images at the same time. Therefore, the effectiveness of an animation treatment in a contiguous presentation may not be the same as in a simultaneous presentation (Moreno & Mayer, 1999; Most & Greenbank, 2000).

Visuals and contiguity

When creating instructional materials, incorporating visuals with text is an effective way to deliver content to students because (a) “visuals help to attract and hold learners’ interest, and visuals reinforce and clarify verbal concepts” (Heinich, Molenda, Russell & Smaldino, 1999, p. 51) and (b) a concept that cannot be fully explained in text may be effectively reinforced by incorporating visuals. Visuals are called images. Among still and moving images, graphics are frequently used in instructional presentations (Heinich, Molenda, Russell & Smaldino, 1999), and an arrow among graphics is typically utilized in order to point out specific text or an image, called as a visual cue.

Arrows as still graphics can also be a way of animation and be contiguously or simultaneously presented with text on an electronic presentation, because still graphics can be animated by computer manipulation. However, the effectiveness of contiguous display of animated arrows may be different from the effectiveness of simultaneous display of animated arrows. It is possibly because (a) there may be a risk to distract students' perception when animated arrows are simultaneously presented with text due to cognitive overload or (b) due to visual attention of the display of animated arrows, there may be a chance to lead students to misunderstand images or texts when the contiguous display of animated arrows is incorrectly presented (Deubel, 2003; Friesen, Ristic & Kingstone, 2004; Gassaway, Davis & Gregory, 1996). Consequently, because the effectiveness of animated arrows is dependent upon how they are presented, studies based upon contiguity may assist in further understanding of the impact of animated graphics on student learning.

Studies of contiguity

Contiguity in problem-solving tests. Mayer and Sims (1994) conducted an experiment that provided students with the narrated and animated presentation of how the human respiratory system works. They found that (a) the students provided with text, narration, and animation achieved higher scores on a problem-solving test than did the students provided with text, no narration, and no animation, but (b) significant difference was not found between contiguous and simultaneous presentations with animation and narration. They implied that when a well-designed multimedia material is presented to students, the students may not be affected by the matter of contiguity. In other words, if well-designed, the effectiveness of a contiguous multimedia material may be equivalent to the effectiveness of a simultaneous multimedia material. Also, they suggested that if an experimental task was dealt with others than a problem-solving task, such as a recall task, the results would be different.

Mayer, Steinhoff, Bower and Mars (1995) assigned groups of students to view different types of instructional materials depicting the operation of a bicycle pump. They found that (a) when students viewed the material provided with illustrations presented contiguously, they generated 75 percent more helpful solutions to a problem-solving test than did the students provided with illustrations presented simultaneously, but (b) the impact of a contiguous presentation with irrelevant illustrations to the given text was not significantly different from the impact of a simultaneous presentation with irrelevant illustrations due to possible distraction of the irrelevant information. As a result, the researchers implied that (a) contiguity effect seems to occur in a problem-solving test, (b) the effectiveness of illustrations and animation may be affected by either relevancy or contiguity, and (c) a positive impact of animation is likely to occur in well-designed multimedia materials.

Contiguity in memory tests. Andrade, Kemps, Werniers, May and Szmalec (2002) investigated contiguity by utilizing college students in U.K. and Belgium. The researchers provided students with various types of text, pictures and sound effects and found that (a) contiguous presentation of visual stimuli relative to the given text did not significantly interfere with students' memory in a recognition test of matrix patterns, whereas simultaneous presentation of visual stimuli interfered, (b) when text and visual information were contiguously presented to the students, they performed better in a recall test than did the students who viewed text and visual information simultaneously, but (c) there was no significant difference between students who viewed contiguous or simultaneous presentations in a recognition test when a time interval was involved. As a result, the researchers argued that (a) contiguity may affect students' recognition and recall abilities regardless of relevancy of visual information to the given text and (b) a simultaneous presentation of textual, visual, and auditory information may have less positive impact on student learning than a contiguous presentation of textual, visua,l and auditory information, because the simultaneously loaded information could generate cognitive overload.

Schwoebel and Srinivas (2000) attempted to address whether the recognition of combined viewing is affected by contiguous presentation of objects. In this experiment, thirty-two undergraduates were shown twenty still objects such as mailboxes and hats that were either similar or dissimilar on a computer screen. Each viewing was either contiguously or simultaneously presented to the students. The researchers found that (a) in a recognition test, participants scored higher when viewing dissimilar objects than viewing similar objects regardless of presentation types (simultaneously or contiguously) and (b) participants better recognized similar objects shown contiguously than shown simultaneously, but (c) there was no significant difference between dissimilar objects presented both simultaneously and contiguously. As a result, the researchers postulated that (a) the recognition of combined viewing may be affected by how objects are presented and designed and (b) when similar objects are presented, such objects in a contiguous presentation may be more easily recognized than in a simultaneous presentation because similar objects shown simultaneously may confuse student perception.

Therefore, visual information presented contiguously may be more effective than visual information presented simultaneously in terms of cognitive load. However, it is still not clear that the effectiveness of animated graphics is equivalent to the effectiveness of still graphics based upon contiguity, and previous studies have not sufficiently examined the relationship between animated graphics and recall capacity. For this reason, studies are needed to examine whether contiguously presented animated graphics, such as arrows, could have a positive effect in a recall test.

CHAPTER 3
METHODOLOGY

The purpose of this chapter is to describe the methodology used to investigate the effectiveness of simultaneously and contiguously presented animated graphics on college student recall of information contained in a multimedia instructional presentation. The investigator used quantitative methods to analyze participants' responses in the experiment. In this study, statistical analysis methods of the independent t-test and the analysis of variance (ANOVA) were used to answer the research questions. The results in this study may help instructors in technology education and general education better understand the relationship between animated graphics, contiguity, and student recall that is a part of learning process (Kintsch, 1998).

Participants

A simple random sampling is "a method of sampling for which every possible sample has equal chance of occurring. This provides fairness and also permits inference about the population sampled" (Agresti & Finlay, 1999, p. 18). Considering the simple random sampling method, students from the College of Education at the University of Florida, the population from which the sample was taken, were randomly selected for participating in the experiment. Partially, due to the demographics of the population, female participants in this study outnumbered the male participants (5 of male and 11 of female in the pilot study; 17 of male and 46 of female in the main experiment). As shown in Table 3-1 and Table 3-2, this experiment utilized sixteen participants for the pilot study and sixty-three participants for the main experiment. Descriptions of the each of three separate groups for the pilot study and main experiment are presented below. Also, even though the participation in the experiment was voluntary and there was no academic compensation, all participants who had completed the experiment were paid ten dollars.

Table 3-1 Descriptions Of The Sample In The Pilot Study

		Control Group	Treatment Group A	Treatment Group B
Number of Participants		5	6	5
Age	Older than 18	5	6	5
	Younger than 18	0	0	0
Gender	Male	2	2	1
	Female	3	4	4

Table 3-2 Descriptions Of The Sample In The Main Experiment

		Control Group	Treatment Group A	Treatment Group B
Number of Participants		21	20	22
Age	Older than 18	21	20	22
	Younger than 18	0	2	0
Gender	Male	5	7	5
	Female	16	13	17

Participants were assigned to each of three separate groups: control group, treatment group A, and treatment group B (*see* Table 3-4). Also, all participants were tested at different locations for the experiment; classrooms at Norman Hall and Terrace room. According to registration records at the University of Florida (Office Of Institutional Research, 2004), the average age for full time undergraduate students at U.F.

was 21.1. However, the investigator ensured the age qualification criteria. In the main experiment, two participants were disqualified, because their age was younger than eighteen years old so that the responses of the disqualified students were not included in statistical analysis.

A Pilot Study And A Main Experiment

Prior to conducting the formal experiment with the participants, the experimental materials were evaluated and validated by two content experts in terms of content validity; one content expert was an educational technologist in higher education, and another content expert was a web master and technology teacher in secondary education. Also, in order for the investigator to establish reliability and validity of the measurement instrument and procedures, a pilot study utilizing the results of the pretest and the posttest was conducted. The results from the pilot study were exclusively used to establish reliability and validity of the measurement instrument and procedures. To obtain statistically acceptable reliability and validity, (a) the score of a reliability test of the groups of the pilot study should be higher than .5 and (b) the mean score of each group should be different from the mean scores of the other groups; in other words, the mean differences of three groups in the pilot study should be established, meaning that the participants in each group produce different results, depending upon the experimental treatments more than prior knowledge of the participants. With the pilot study, the investigator found initial results from ANOVA before conducting the main experiment.

In both the pilot study and the main experiment, three experimental groups were tested; control group, simultaneous group (treatment group A) and contiguous group (treatment group B). The control group had no animation treatment, whereas the remaining two groups had animation treatment. The simultaneous group received a simultaneous display of the given text and animated graphics (animated arrows), while the contiguous group received a contiguous display of such information (*see* Table 3-3 and Table 3-4).

Table 3-3 Pretest-Posttest Control-Group Design For The Pilot Study

Group	Treatment Procedure		
Control Group	O_1 Pretest	Tc No Treatment	O_2 Posttest
Treatment Group A	O_1 Pretest	Ta Treatment	O_2 Posttest
Treatment Group B	O_1 Pretest	Tb Treatment	O_2 Posttest

Table 3-4. Pretest-Posttest Control-Group Design For The Experiment

Group	Treatment Procedure		
Control Group	O_1 Pretest	Tc No Treatment	O_2 Posttest
Treatment Group A	O_1 Pretest	Ta Treatment	O_2 Posttest
Treatment Group B	O_1 Pretest	Tb Treatment	O_2 Posttest

Experimental Procedure

The experiment of the pilot study and main experiment was conducted in accordance with the following experimental procedures:

1) The participants were informed of what they do in the experiment, reminded of their voluntary participation, notified of the participation compensation, and informed that they should voluntarily sign the informed consent form and return it to the investigator.
2) All participants were randomly assigned to the experiment groups: control group, treatment group A and treatment group B.
3) The participants took a pretest with paper-based materials prior to viewing a presentation.

4) The participants viewed a presentation about learning to insert information in a web page, which was operated by the automatic slide show function embedded in Microsoft PowerPoint presentation tool.
5) After viewing a presentation, participants took a posttest with paper-based materials, which solicited their responses to questions that were measuring participants' recall of the information contained in the electronic presentation.
6) The experiment took about one hour to be complete.

The experimental procedures assumed the following:

Each participant had equal access to the instructional presentation created by Microsoft PowerPoint presentation tool. This experiment did not consider the external minor distractions such as noise of a projector. However, major distractions such as loud chatting among participants were prohibited due to the potential external distraction. Persons other than the participants, investigator, and instructor were not allowed to be in an experiment place.

Experiment Materials

Pretest And Posttest

For both the pretest and the posttest, a multiple-choice method was used. The multiple-choice method, one of the objective-based measurement methods, helps researchers objectively examine students' learning achievement (Linn & Gronlund, 2000). In order to construct a pretest and a posttest properly, the investigator applied the following evaluation guidelines into test items: An item should be meaningful by itself. An item should contain only one correct or clearly best answer. Typically, an item should be positively stated. All of the alternatives should be grammatically consistent (Linn & Gronlund, 2000). The questions in both the pretest and the posttest were randomly assigned according to the table of random numbers (Kranzler, 2003), (*see* Contents Of A Pretest And A Posttest). Also, each question in a pretest and a posttest provided the participants with four alternatives; a participant may choose a correct or best choice.

Pretest

A pretest contained questions soliciting a participant's prior knowledge of educational media technology such as photo editing and Internet browsing, and the pretest served as a diagnostic assessment for prior knowledge (*see* Content Of Pretest).

Posttest

The questions in the posttest were different from the questions in the pretest. A posttest contained questions soliciting a participant's recall of the information for creating web pages used in a presentation (*see* Content Of Posttest). The order of questions in a posttest were randomly assigned according to the table of random numbers (Kranzler, 2003).

Multimedia Presentation

The experimental multimedia presentation was created by Microsoft PowerPoint application, operated by IBM PC platform, and projected by SANYO multimedia projector on the screen in the experiment places. The information for creating web pages was stored in slides of a Microsoft PowerPoint presentation. The questions in a posttest determined whether a participant retained certain information used in the presentation. The presentation in this experiment was a ten-minute instructional presentation: the given content in the presentation was solely used for the purpose of measuring participants' recall. The presentation consisted of twenty-seven slides, including the presentation title (*see* Content Of Multimedia Presentation). The format of the presentations for each of the three groups was constructed as follows (*see* Tables 3-3, 3-4, 3-5, and 3-6): The presentation for the control group had no animation treatment, but it had still images; the presentation for the simultaneous group (treatment group A) had the treatment of simultaneous display of the given text and animated graphics (animated arrows); the presentation for the contiguous group (treatment group B) had the treatment of contiguous display of the given text and animated graphics (animated arrows).

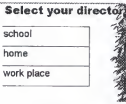
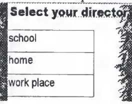
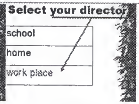
Table 3-5. Types Of Treatments

	Simultaneous Display	Contiguous Display
Control Group	None	None
Treatment Group A	Treated (animated arrows)	None
Treatment Group B	None	Treated (animated arrows)

While a participant viewed the presentation slides, each slide was automatically replaced with the next slide; a participant had a fixed amount of time to view a slide. The presentation format selected for this study was Microsoft PowerPoint. In terms of quality and complexity of animation, the animated graphics utilized in this experiment were simple animations, compared to complex animations; simple animations are to show only visual stimulus and to have no specific meaning per se, whereas complex animations are to show both visual stimulus and specific meaning per se and to be comprised of more than two different moving images. In this study, PowerPoint was solely utilized as a content delivery system of text and animation for the experiment, and the participants in three experimental groups viewed each presentation slide in which the length of viewing time was fixed, indicating that the participants could not change the viewing time by themselves.

Table 3-6. A Sample Of Contiguous Display In The Treatment Group B

1) Frame 1: only still graphics and texts are appeared, not animation.
2) Frame 2 and 3: animated arrows are successively appeared until the next slide comes in.

	Example		
Animated Graphics (Arrows)			
	frame 1	frame 2	frame 3

Statistical Analysis Design

The investigator utilized the analysis of variance with pretest-posttest control-group design (ANOVA) and the independent t-test. ANOVA was conducted to see if there was a significant difference between the presentations provided with different types of animated graphics display. In addition, the independent t-test was conducted to see if there was a significant difference between the presentation without animated graphics and the presentations with animated graphics.

Analysis Of Variance

In one-way analysis of variance, recall in the cognitive domain served as the dependent variable. The recall variable meant how much specific information each participant retained and how correctly s/he responded to questions in the pre- and post-tests; each recall-testing item had only one correct or best answer. Main effects among the control and treatment groups were measured in *p* value, < .05, as the investigator examined the main effects (Shavelson, 1996; Stricker & Emmerich, 1999).

The pretest-posttest control-group design in this experiment was used in order to measure treatment effects. It is because even though the pretest-posttest control-group design is similar to the posttest-only control-group design, the pretest-posttest control-group design has an advantage that “adds an observation prior to treatment implementation” (Shavelson, 1996, p.25). In addition, pretest questions were limited, as “pretests are typically limited in scope” (Linn & Gronlund, 2000, p.140).

Assumptions of data analysis method

The analysis of variance (ANOVA) is a method to assess null hypotheses in which group means are equal in population and mainly compares the sample variance estimated from the group means. In the ANOVA, dependent variables should be quantitative, and factors should be categorical. The assumptions in the ANOVA are the following: as data are the random sampling from a normal population, the cell variances are the same value; as the data could be symmetric, the ANOVA should be robust from the normality (Agresti & Finlay, 1997; Wonnacott & Wonnacott, 1985). As standard deviation of the population is smaller, the power probability is greater, because overlap between the sampling distribution under the null and alternative hypotheses is decreased, which may increase the statistical power. Among several ways to control the standard deviation of the population, one way to increase the power is to reduce the error variance. Reducing the error variance refers to decreasing the heterogeneity of the groups. For this reason, this study utilized students at the University of Florida only in order for the investigator to possibly implement both random and robust sampling methods.

Research Hypotheses

As the investigator utilized the independent t-test and ANOVA with pretest-posttest control-group design, the null (Ho) hypotheses were respectively constructed as follows:

Hypothesis 1

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 2

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the simultaneous display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 3

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the contiguous display of animated graphics and viewing the presentation without the display of animated graphics.

Hypothesis 4

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with contiguous display of animated graphics and viewing the presentation with simultaneous display of animated graphics.

Ethical Assurance

The investigator received informed consent forms from the participants when conducting the experiment. Informed consent forms were approved by the Institutional Review Board at the University of Florida (UFIRB-02). It describes (a) the nature and purpose of this study, (b) the procedures to be followed, (c) the confidentiality of research data and (d) the voluntary participation as advised. It additionally indicates that voluntary participations would not affect the participants' academic consequences in any way. Besides, the participants were provided with personal information of the investigator's and supervisor's names, addresses, e-mails, and phone numbers for participants' questions and concerns about the experiment.

CHAPTER 4
RESULTS

The purpose of this study was to examine the impact of animated graphics on college student recall of information presented in an electronic presentation. Three different treatments of the presentation regarding how to insert an image and a table on a web page were utilized to determine statistical main effects between three experimental groups. To test the null hypotheses stated in the methodology, analysis of variance with pretest-posttest control-group design (ANOVA) and independent t-test were conducted. Presented in this chapter are the results of the data analysis.

Pilot Study

The investigator conducted a pilot study in order to establish the validity of the experimental procedures and design, which allowed the investigator to conduct the main experiment (Agresti & Finlay, 1999) and found initial results of the recall.

Treatment

The pilot study consisted of a pretest, a PowerPoint presentation, and a posttest. Before viewing the presentation, the participants took the pretest. They took the posttest after viewing the presentation. The entire experimental procedure took about one hour.

The control group viewed the presentation without the experimental treatments. Each of the remaining two groups was provided with a specific experimental treatment. The simultaneous group (treatment group A) was provided with animated graphics presented simultaneously with the text, and the contiguous group (treatment group B) was provided with animated graphics presented contiguously with the text.

Descriptive Statistics Of The Sample

The participants, as a representative sample of college students at the University of Florida, were randomly selected for the pilot study by the investigator. The total number of participants was sixteen, and they were assigned to one of three groups: control group (*n*=5), simultaneous group (*n*=6), and contiguous group (*n*=5). As shown in Table 4-1, the mean score of each group in the posttest (recall) differed from the others: control group (*M*=5.80, *SD*=1.30), simultaneous group (*M*=7.17, *SD*=. 41), and contiguous group (*M*=7.00, *SD*=1.22).

Table 4-1. Descriptive Statistics Of The Sample In The Pilot Study

RECALL

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Control	5	5.80	1.30	.58	4.18	7.42	5	8
Simultaneous	6	7.17	.41	.17	6.74	7.60	7	8
Contiguous	5	7.00	1.22	.55	5.48	8.52	5	8
Total	16	6.69	1.14	.28	6.08	7.29	5	8

Recall ANOVA

As shown in Table 4-2, the ANOVA for recall results in the pilot study indicated that no significant difference was found between groups in the posttest, F (2, 13)=2.767 (*p*=. 011). Consequently, the differences between the groups were not statistically significant, even though the experimental treatments for the posttest were utilized.

Table 4-2. Analysis Of Variance In The Pilot Study

RECALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.804	2	2.902	2.767	.100
Within Groups	13.633	13	1.049		
Total	19.438	15			

Reliability Testing

As shown in Table 4-3, the mean score of participants' pretest (*M*=3.500, *SD*=1.751, *n*=16) differed from the mean score of participants' recall (*M*=6.687, *SD*=1.138, *n*=16), and the mean scale was 10.1875.

Table 4-3. Reliability Analysis – Scale (Alpha)

```
                                 Mean          Std Dev         Cases
  1.      PRETEST              3.5000           1.7512          16.0
  2.      RECALL               6.6875           1.1383          16.0
  N of Cases = 16.0

Statistics for         Mean   Variance      Std Dev    N of Variables
          Scale    10.1875     5.7625       2.4005           2

   Reliability Coefficients      2 items
   Alpha =. 5859           Standardized item alpha =. 5198
```

However, this data set did not verify reliability because the content of the pretest was not identical to the content of the posttest, suggesting that the content of such tests may violate internal validity (Agresti & Finlay, 1999; Shavelson, 1996). In order for the investigator to establish statistical reliability of scale measurement between the pretest and the posttest, a Reliability Analysis-Scale (Alpha) was conducted. An Alpha score of reliability coefficients for the two items (pretest and posttest) was .5859 ($\alpha > .5$), and a Standardized Item Alpha score was .5198 ($\alpha > .5$). As a result, reliability between the pretest and the posttest was statistically established because the reliability score was higher than .5, indicating that internal validity of the scale measurement was not violated (Kranzler, 2003).

Summary

The investigator conducted a pilot study to establish the validity and reliability of experimental procedures. The results of the pilot study showed that even though no significant statistical difference was found between treatment groups in the ANOVA, the mean score of each group differed from the others, indicating that experimental treatments may have differentiated the participants' responses in the posttest. Additionally, reliability analysis with the pilot study was conducted to establish internal validity of scale measurement. The results of the analysis demonstrated that reliability of the pretest and the posttest was statistically established, indicating that the participants' responses in the posttest were more possibly affected by the experimental treatments than by prior knowledge of the participants.

Main Experiment

The participants of this experiment were randomly selected students at the University of Florida. The total number of the participants was sixty-three. The participants were randomly assigned to one of three experimental groups: control group (*n*=20), simultaneous group (*n*=21, original *n*=23), and contiguous group (*n*=22). However, two participants in the simultaneous group were disqualified for statistical analysis because they were younger than eighteen years old.

Treatment

For the main experiment, the investigator utilized the same experimental treatments and procedures as were utilized in the pilot study.

Descriptive Statistics Of The Sample

The mean score of each group in the posttest (recall) differed from the others in general. As shown in Table 4-4, the mean score of the control group (*M*=6.24, *SD*=2.10) was lower than the mean scores of the simultaneous group (*M*=6.45, *SD*=1.73) and the contiguous group (*M*=7.73, *SD*=1.42).

Table 4-4. Descriptive Statistics Of The Sample By Group

RECALL

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Control	21	6.24	2.10	.46	5.28	7.19	0	9
Simultaneous	20	6.45	1.73	.39	5.64	7.26	3	10
Contiguous	22	7.73	1.42	.30	7.10	8.36	4	10
Total	63	6.83	1.86	.23	6.36	7.29	0	10

Recall Independent T-Test

An independent t-test was conducted to see if there was significant difference between the presentation without animated graphics and the presentations with animated graphics. Also, the t-test was analyzed to examine null hypothesis 1. As indicated in Table 4-5, the mean score of control group (*M*=6.24, *MD*=2.10) in the posttest (recall) differed from the mean score of combined simultaneous and contiguous groups (*M*=7.24, *MD*=1.71). Also, as shown in Table 4-6, significant difference was found between the control group and the combined simultaneous and contiguous groups at the .05 level of significance (*p*=. 047). Consequently, compared to the participants of the control group, statistically significant difference in the participants of the simultaneous and contiguous groups was indicated by the experimental treatments for the posttest that solicited each participant's recall of the information.

Table 4-5. Descriptive Statistics Of The Sample

	Group	N	Mean	Std. Deviation	Std. Error Mean
RECALL	Control	21	6.24	2.10	.46
	Simul+Contigu	42	7.24	1.71	.26

Table 4-6. Independent T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RECALL	Equal variances assumed	.001	.977	-2.029	61	.047*	-1.00	.49	-1.99	-1.45E-02
	Equal variances not assumed			-1.895	33.684	.067	-1.00	.53	-2.07	7.29E-02

* The significant difference is at the .05 level.

Recall ANOVA

As shown in Table 4-7, F (2, 60)=4.482 (*p*=. 015) in the ANOVA indicated that significant difference was found between groups for main effects in the posttest (*p*=. 015). Also, multiple comparisons by ANOVA post hoc test (Tukey HSD) was performed for further analysis. As shown in Table 4-8, comparisons between the control and contiguous groups produced statistically significant difference (*MD*= -1.49, *p*=. 020), whereas no significant difference was found in the group comparisons between the control and simultaneous groups (*MD*= -.21, *p*=. 922) and between the simultaneous and contiguous groups (*MD*= -1.28, *p*=. 058). Consequently, compared to the participants of the control group, statistically significant difference in the participants of the contiguous group was indicated by the experimental treatments for the posttest that solicited each participant's recall of the information.

Table 4-7. Analysis Of Variance In The Main Experiment
RECALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	27.956	2	13.978	4.482	.015
Within Groups	187.123	60	3.119		
Total	215.079	62			

Table 4-8.Multiple Comparisons By ANOVA Post Hoc Test
Tukey HSD; Dependent Variable: RECALL

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) Group	(J) Group				Lower Bound	Upper Bound
Control	Simultaneous	-.21	.552	.922	-1.54	1.11
	Contiguous	-1.49*	.539	.020	-2.78	-.19
Simultaneous	Control	.21	.552	.922	-1.11	1.54
	Contiguous	-1.28	.546	.058	-2.59	3.40E-02
Contiguous	Control	1.49*	.539	.020	.19	2.78
	Simultaneous	1.28	.546	.058	-3.40E-02	2.59

* The mean difference is significant at the .05 level.

Hypotheses Testing

The following null hypotheses, as described in the methodology, were tested by the methods of independent t-test and analysis of variance with p value < .05.

Hypothesis 1

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the display of animated graphics and viewing the presentation without the display of animated graphics.

To test hypothesis 1, an independent t-test was conducted, and a summary of the independent t-test was represented in Tables 4-5 and 4-6. The result demonstrated that there was a significant difference between the control group and the combined simultaneous and contiguous groups at the .05 level of significance, indicating that the treatment effect occurred (*MD*=-1.00, *p*=. 047). Therefore, null hypothesis 1 was rejected.

Hypothesis 2

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the simultaneous display of animated graphics and viewing the presentation without the display of animated graphics.

To test hypothesis 2, ANOVA and multiple comparisons by ANOVA post hoc test (Tukey HSD) were conducted, and a summary of the ANOVA statistics are shown in Tables 4-7 and 4-8. The ANOVA Post Hoc Test (Tukey HSD) demonstrated that a statistically significant difference was not found between simultaneous group and control groups (*MD*=. 21, *p*=. 922). Therefore, null hypothesis 2 was not rejected.

Hypothesis 3

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the contiguous display of animated graphics and viewing the presentation without the display of animated graphics.

As shown in Table 4-8, the ANOVA Post Hoc Test (Tukey HSD) demonstrated that a statistically significant difference was found between contiguous group and control group, indicating that the treatment effect occurred (*MD*=1.49, *p*=. 020). Therefore, null hypothesis 3 was rejected.

Hypothesis 4

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with contiguous display of animated graphics and viewing the presentation with simultaneous display of animated graphics.

To test hypothesis 4, multiple comparison by ANOVA post hoc test (Tukey HSD) was examined. As shown in Table 4-8, Tukey HSD demonstrated that no significant difference was found between contiguous group and simultaneous group, indicating that the treatment effect did not occur (*MD*=1.28, *p*=. 058). Therefore, null hypothesis 4 was not rejected.

Summary

The results of the data analysis indicate the following.

As examined with recall independent t-test, the presentation with animated graphics resulted in a significant impact on participants' recall of information at the .05 level of significance, compared to the presentation without animated graphics. Also, as examined with recall ANOVA, the presentation with contiguous display of animated graphics resulted in a significant impact on participants' recall of information at the .05 level of significance, compared to the presentation without display of animated graphics. However, a significant difference was not found between control group and simultaneous group as well as between simultaneous group and contiguous group.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This study was designed to examine the impact of animated graphics on college student recall by utilizing three different treatments of the display of animated graphics in electronic presentations. Specifically, the study examined the differences in recall of information contained in presentations utilizing simultaneous display of animated graphics, contiguous display of animated graphics, and without the use of any animation. Four research questions were raised for this study.

> Question 1: Do students better recall techniques used for inserting information as a component of web page development in a presentation that displays animated graphics than do students who receive the presentation without the display of animated graphics?
>
> Question 2: Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the simultaneous display of animated graphics than do students who receive the presentation without the display of animated graphics?
>
> Question 3: Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the contiguous display of animated graphics than do students who receive the presentation without the display of animated graphics?

Question 4: Do students better recall techniques used for inserting information as a component of web page development in a presentation that uses the contiguous display of animated graphics than do students who receive the presentation with the simultaneous display of animated graphics?

Findings

Hypothesis 1

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the display of animated graphics and viewing the presentation without the display of animated graphics.

A significant difference was found to exist between the presentation with the display of animated graphics and the presentation without the display of such animation. The null hypothesis was rejected at the .05 level of significance.

Hypothesis 2

There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the simultaneous display of animated graphics and viewing the presentation without the display of animated graphics.

A significant difference was not found to exist between the presentation with the simultaneous display of animated graphics and the presentation without the display of such animation. The null hypothesis was not rejected at the .05 level of significance.

Hypothesis 3

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the contiguous display of animated graphics and viewing the presentation without the display of animated graphics.

A significant difference was found to exist between the presentation with the contiguous display of animated graphics and the presentation without the display of such animation. The null hypothesis was rejected at the .05 level of significance.

Hypothesis 4

> There is no significant difference in recall of techniques used for inserting information as a component of web page development when viewing the presentation with the contiguous display of animated graphics and viewing the presentation with the simultaneous display of animated graphics.

A significant difference was not found to exist between the presentation with the contiguous display of animated graphics and the presentation with the simultaneous display of such animation. The null hypothesis was not rejected at the .05 level of significance.

Discussion

Since recall is generally considered a part of the learning process (Hack, 2004; Kintsch, 1998) and research has shown that cognitive overload is a major problem in electronic learning (Demirbilek, 2004; Hartley & Bendixen, 2003), the primary interest of this study was to find how various treatments of animated graphics might affect student recall, compared to no display of animated graphics. Investigator expected that the use of graphics would be better than no use of graphics. Additionally, the investigator expected that the contiguous display of animated graphics with text might attenuate cognitive overloading that could be generated by a simultaneous display (Mayer & Moreno, 2003; Paas, Renkl, & Sweller, 2003).

Published research on the impact of simultaneous and contiguous displays of animated graphics in electronic presentations on college student recall appears to be non-existent prior to this study. In this study, the investigator was interested in determining the impact of animation on recall, as well as examining the difference between simultaneous and contiguous displays of animated graphics in electronic presentations. There was significant difference between the control group (receiving the presentation without animated graphics) and the combined simultaneous and contiguous groups (receiving the presentation with animated graphics). There was also significant difference between the control group and the contiguous group (receiving the presentation with the contiguous display of animated graphics). However, no significant difference was found between the control group and the simultaneous group (receiving the presentation with the simultaneous display of animated graphics) or between the simultaneous group and the contiguous group, even though significance *p* value (*p*=. 058) was close to the .05 level of significance.

As this study found a positive impact of animated graphics on student recall by utilizing independent t-test, the results support that students who receive the electronic presentation with animated graphics may recall better than do students who receive the electronic presentation without animated graphics. This is consistent with previous studies, which reported that animation use in electronic learning seemed to help student recall the given information in electronic learning materials (Mayer & Moreno, 2002; 2003; Paas, Renkl, & Sweller, 2003; Sweller, 1999; Sweller & Chandler, 1991). Considering the results of the current and previous studies, instructors should consider including animated graphics in electronic materials to assist student recall.

The results of the statistical measures needed in this study determined that the simultaneous display of animated graphics did not have a positive impact on student recall, compared to no display of animated graphics, whereas the contiguous display of animated graphics did have a positive impact on student recall, compared to no display of animated graphics. Initially, the investigator assumed that a simultaneous display of the given textual and visual information could generate cognitive overloading, whereby a contiguous display of the given textual and visual information would not generate cognitive overloading.

As the investigator expected that recall in the simultaneous group would not produce significant difference from the control group due to the possible occurrence of cognitive overloading whereas recall in the contiguous group would produce significant difference, this study found the expected results. This appears to support recent studies of learning disorientation in an electronic learning environment by Demirbilek (2004) and Yeung (1999). Demirbilek states that the recall capacity of students in an electronic learning environment may be decreased due to the occurrence of cognitive overloading generated by too much information presented simultaneously. Also, Yeung demonstrates that simultaneous input of textual and visual information is more likely to result in cognitive overload than simultaneous input of textual information only. According to the study by Yeung, when students receive both textual and various visual information (pictures, graphics, animation, and other types of visual stimuli) at the same time, they may experience ineffective learning because they are required to simultaneously execute different information processes as a result of the distinct nature of textual versus visual information.

Consequently, the current results of group comparisons between the simultaneous group and the control group and between the contiguous group and the control group indicate that although the animated graphics (arrows) served as visual cues that might attain student attention in the experimental presentations, the use of animated graphics seems to be less effective when simultaneously presented with the text than contiguously presented with the text. Also, these results indicate that instructors should incorporate contiguous rather than simultaneous displays of animated graphics in the electronic presentations they produce.

The positive impact of the contiguous display of animated graphics with the text found in this study seems to corroborate the study by Tripp and Roby (1990). Tripp and Roby state that student learning outcome in an electronic learning environment may be increased as cognitive overloading is decreased, and that the possible occurrence of cognitive overloading may be associated with how different information is presented in an electronic presentation. This study demonstrated that student recall in the contiguous group was higher than in the control group. Thus, students who received the contiguous display of information seemed not to be impacted by cognitive overloading. This result supports previous studies shown that contiguity effects may reduce cognitive overloading which were possibly generated by a simultaneous input of various information (Paas, Renkl, & Sweller, 2003; Sweller & Chandler, 1991). Therefore, this study suggests that an electronic presentation with the contiguous display of text and animated graphics seems to enable students to retain information better than an electronic presentation with no animated graphics, whereas an electronic presentation with the simultaneous display does not.

However, even though the mean score of the contiguous group was higher than the mean score of the simultaneous group, surprisingly, no significant difference was found between the two groups. The expectation was that contiguous group would perform significantly better than the simultaneous group. The possible reasons for the lack of significance are important to assess.

First, in order to examine the group comparisons based upon statistical analysis, the investigator used an ANOVA post hoc test by Tukey HSD. Interestingly, the method of post hoc tests used may impact the determination of significant difference between groups. As this study utilized ANOVA post hoc test by Tukey HSD for multiple group comparisons, the significant difference was not found between the contiguous group and the simultaneous group. However, because the analysis showed that statistical significance *p* value ($p= .058$) was close to the .05 level of significance for the group comparison, the investigator utilized another analysis method. Interestingly, the new method of LSD (Fisher's Least Significant Difference) showed that significant difference ($p= .023$) was found between the contiguous group and the simultaneous group at the .05 level of significance (*see* Multiple Comparisons Of ANOVA Post Hoc Test With Tukey HSD And Fisher's LSD). This new result indicates that when conducting multiple group comparisons, the occurrence of statistical significance between groups is dependent upon which post hoc test is utilized. According to Shavelson (1996), conducting an analysis with Tukey HSD (Honestly Significant Difference) is more appropriate for an experiment with large sample size than Fisher's LSD because the determination rule of significance in Tukey HSD is more restricted than in Fisher's LSD. As a result, the lack of significance between the contiguous group and the simultaneous group, opposed to the expectation, resulted from the selection of post hoc tests, and this reason may suggest that a follow-up study may need to test a larger sample size in order to utilize Tukey HSD.

A second possible reason for the lack of significant difference between the contiguous group and the simultaneous group might be explained by the pattern of the mean scores of multiple group comparisons. After examining each group comparison, the mean score of the contiguous group (M=7.73) was higher than the mean score of the control group (M=6.24), and the mean score of the simultaneous group (M=6.45) was also higher than the mean score of the control group. Relatively, the mean score of the simultaneous group has come to be between the mean scores of the contiguous and control groups; the contiguous group > the simultaneous group > the control group. For this reason, although the students in the contiguous group performed better in the recall task than the students in the simultaneous group, the mean difference was not able to show significance due to the narrow mean difference.

In conclusion, this study suggests that use of animation in electronic presentations may help college students recall information contained in the presentation. In addition, a contiguous display of animated graphics may improve recall capacity of college students and enable them learn better than with no display of animated graphics. For this reason, instructional designers and instructors in higher education are encouraged to incorporate animation with text and to present the instructional information in a presentation slide or a multimedia presentation page contiguously. In addition, the instructional designers and instructors need to be aware of the fact that the effectiveness of simultaneous presentations is not equivalent to the effectiveness of contiguous presentations because a simultaneous presentation of the instructional information may generate cognitive overload and/or split-attention that could hinder college student recall process.

Recommendations For Future Studies

This study produced several statements that may be of interest to future researchers, and the statements are presented below as recommendations for future studies.

First, in terms of quality and complexity of animation, the simple animated graphics (animated arrows) were utilized in this study. A future study may find different results if experimental materials are incorporated with more complex animations than the current animations.

Second, the sample in this study was limited to the students from the College of Education at the University of Florida. This study had more female participants than male participants (female was 73 percent of total number of the participants; 46 of female and 17 of male in the main experiment). As a result, this might affect the generalization of the study to a larger population, since the findings were limited geographically and by the characteristics of the sample participants. Future studies may conduct an experiment with participants from other academic venues and with different gender ratios such as male only, female only, and equal gender ratios.

Third, the time interval between the pretest and the posttest in this study was only about fifteen minutes. If this study had utilized a greater time interval, the results may have varied because time interval has been shown to be an important variable for recall in previous studies (Carpenter, Miyake, & Just, 1994; Martin-Michiellot & Mendelsohn, 2000). Because the length of viewing time of both the presentation and each presentation slide in this study was fixed for all the participants, the results of a future study may vary if the study differentiates the length of viewing time (either shorter or longer than current fixed time).

Fourth, because the experiment concerned visual modality, as opposed to multiple-modalities (visual and auditory), different results could be found if the experimental materials had been designed based upon multiple-modalities. Thus, a future study may consider multiple-modalities. Specifically, if an experiment uses with both visual and auditory modalities, results may be dissimilar to the current results because student learning is also impacted by auditory information (Mayer & Moreno, 2002; 2003). In addition, a previous study of multiple-modalities (Grace-Martin, 2001) indicates that the material designed based upon multiple-modalities may create more "cognitive load accompanied by relatively less overall knowledge activation" (p. 404) than the material designed based upon a single-modality because concurrent input of textual, visual, and auditory information is likely to generate cognitive overloading. For this reason, a future study may need to examine the assumption that a simultaneous display of animated graphics with text and audio may generate more cognitive overloading than a simultaneous display of animated graphics with text and no audio in electronic presentations.

Last, because student learning is dependent upon relevancy of background knowledge (Kintsch, 1998) and student achievement in electronic learning is dependent upon "learner's experience, background and perspective" (Demirbilek, 2004, p.76), the investigator was additionally interested in determining whether prior knowledge of the participants might be associated with current information recall. Interestingly, the result did not find statistically significant correlation in the simultaneous group and the contiguous group (*see* PPM Correlation Between Pretest And Recall By Group Comparisons). This means that the participants who scored higher than the mean score in the pretest might not score higher than the mean score in the posttest (Agresti & Finlay, 1999). In addition, it indicates that the participants who scored higher than the mean score in the posttest seemed to be more affected by the experimental treatments than by their prior knowledge. This result was dissimilar to the results of previous studies (Gerjets & Scheiter, 2003; Peereman, Content, & Bonin, 1998). Gerjets and Scheiter state that student response in an experiment with visual treatments is affected by the individual's prior knowledge because prior knowledge impacts individual's information processing. Also, according to the study by Peereman, Content, and Bonin, the possibility of positive impact of moving images on student learning may be dependent upon students' prior knowledge and their previous visual experiences. However, prior knowledge of the participants in the simultaneous and contiguous groups seemed not to affect their recall significantly because statistically significant correlation between the pretest and posttest was not found, even though correlations (r=. 372 in the simultaneous group; r=. 350 in the contiguous group) had occurred at the .05 level of significance. As a result, a future study may need to examine such a discrepancy in the relationship between prior knowledge and recall task.

APPENDIX A
CONTENT OF PRETEST

1. Which of the following is not necessary for web page creation?
   - a. Computer
   - b. Web page editor program
   - c. File transfer program
   - d. Still camera (regular camera)

2. Which of the following is the best example for the most common e-mail coding in the web page editing?
   - a. mailto:jason456@ufl.edu
   - b. mail to:jason456@ufl.edu
   - c. postto:jason456@ufl.edu
   - d. post to:jason456@ufl.edu

3. Which one of the following is for movie file format?
   - a. GIF
   - b. JPEG
   - c. MPEG
   - d. DOC

4. What does "Pixel number" mean in terms of photo density?
   - a. Total numbers in two-inch square space on a photo.
   - b. Total numbers in one-inch square space on a photo.
   - c. Total numbers in two-inch-diameter circle space on a photo.
   - d. Total numbers in one-inch-diameter circle space on a photo.

5. Which of the following is not for Internet service provider?
   - a. American Online
   - b. Microsoft Network
   - c. Netscape
   - d. Digitas

6. What does JPEG stand for?
   - a. Joint Photographic Exchange Group
   - b. Joint Personal Electronic Graphics
   - c. Joint Photographic Experts Group
   - d. Joint Photographic Experts Graphics

7. What does "WWW" stand for?

a. World Wireless Web
b. World Wide Wire
c. World Wide Web
d. Wireless Wide Wire

8. Which of the following is not for photo file format?
   a. GIF
   b. JPEG
   c. TIFF
   d. MOV

9. Which of the following is least important when creating web pages?
   a. Audience
   b. Design Clarity
   c. Accurate Information
   d. Webmaster Information

10. Which of the following is a correct statement about digital video editing?
   a. Digital video cannot store still pictures
   b. Digital video can store moving pictures, but not sound
   c. Digital video cannot store moving pictures
   d. Digital video can store both moving pictures and sound

APPENDIX B
CONTENT OF POSTTEST

1. What kinds of factors do tables consist of in a web page?
    a. Rows
    b. Rows and Columns
    c. Rows, Columns and Cells
    d. Rows, Columns, Cells and Pixels

2. This presentation has been designed to help students learn ______ skills.
    a. Technical
    b. Written
    c. Theoretical
    d. Operational

3. Which of the following is the correct order for inserting an image?
    a. Click Insert → Picture → Clip Art
    b. Click Picture → Clip Art → Insert
    c. Click Insert → Clip Art → File
    d. Click Picture → Clip Art → File

4. After clicking an image that is chosen for inserting, what is the following step to insert the image on a web page?
    a. Click Insert Clip
    b. Click Insert Table
    c. Click Insert Clip Art
    d. Click Insert File

5. This presentation will provide students with information of ______ skills needed to design a web page.
    a. Inserting
    b. Downloading
    c. Publishing
    d. Cutting

6. After typing a number of rows and columns for inserting, what is the following step to insert a table on a web page?
    a. Click File
    b. Click O.K.
    c. Click Save

d. Click Table

7. An image illustrates a concept or enhances the ______ of a web page
    a. Volume Of Text
    b. Speed To Be Operated
    c. Appearance
    d. Title
8. After a table is inserted, which of the following is needed to add text on the table?
    a. Click On A Cell
    b. Click On A Vertical Line
    c. Click On A Horizontal Line
    d. Click On Save

9. Students will be able to insert images and ______ on a web page.
    a. Tables
    b. Videos
    c. Music Clips
    d. Sound Effects

10. Which of the following is the correct order when inserting tables?
    a. Click Table → Insert → Table
    b. Click Insert → Table → Table
    c. Click Table → Type a number of rows → Select The Location
    d. Click Insert → Type a number of rows → Select The Location

APPENDIX C
CONTENT OF MULTIMEDIA PRESENTATION

Learning To Insert Information In A Web Page

Microsoft FrontPage 2000

Spring 2005 - TGB

Purpose of the Presentation

This presentation has been designed to help students learn technical skills in web page creation.

To do so, the presentation will provide students with the information of inserting skills needed to design a web page.

Objectives of the Presentation

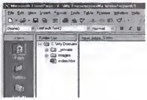
Students will be able to:

1.0 insert images on a web page.

2.0 insert tables on a web page.

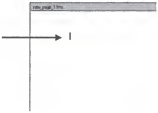
Inserting Images

An image illustrates a concept or enhances the appearance of a web page.

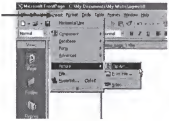


To insert an image:

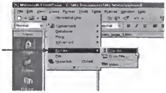
Select the location where you want to add.



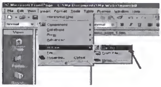
Click **Insert**.



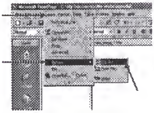
Click **Picture**.



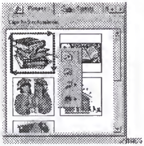
Click **Clip Art**.



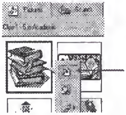
Click **Insert**, **Picture** and **Clip Art**.



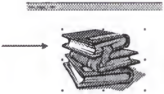
Click an image you want.



Click **Insert Clip**.

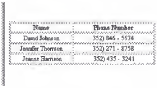


The image is inserted.



Inserting Tables

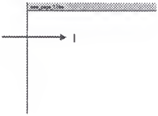
- A table neatly displays a list of information.
- It consists of rows, columns and cells.



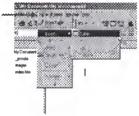
Name	Phone Number
David Johnson	352) 846 - 5674
Jennifer Thornton	352) 271 - 8758
Jeanne Harrison	352) 435 - 3241

To insert a table:

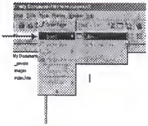
Select the location where you want to add.

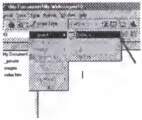
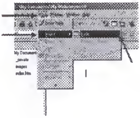
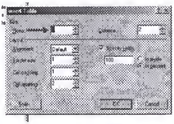
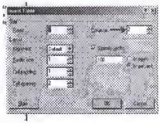
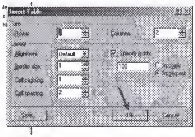
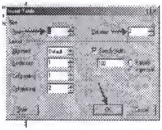
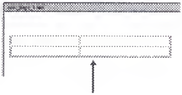
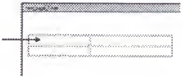


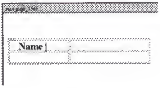
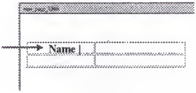
Click **Table.**



Click **Insert.**



Click **Table.** 	Click **Table, Insert** and **Table.** 
Type a number of rows. 	Type a number of columns. 
Then, click O.K. 	Type a number of rows and columns. Then, click O.K. 
The table is inserted. 	To add text, click on a cell. 

Then, type text.  Name	To add text, click on a cell. Then, type text.  Name
The presentation is ended.	

APPENDIX D
THE NUMBERS FOR THE QUESTIONS OF THE PRETEST AND THE POSTTEST

These numbers had been used for assigning each question in the pretest and the posttest.

1. 54463
2. 15389
3. 85941
4. 61149
5. 05219
6. 41417
7. 28357
8. 17783
9. 40950
10. 82995

APPENDIX E
MULTIPLE COMPARISONS OF ANOVA POST HOC TEST WITH TUKEY HSD AND FISHER'S LSD

Dependent Variable: RECALL

			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
	(I) Group	(J) Group				Lower Bound	Upper Bound
Tukey HSD	Control	Simultaneous	-.21	.552	.922	-1.54	1.11
		Contiguous	-1.49*	.539	.020	-2.78	-.19
	Simultaneous	Control	.21	.552	.922	-1.11	1.54
		Contiguous	-1.28	.546	.058	-2.59	3.40E-02
	Contiguous	Control	1.49*	.539	.020	.19	2.78
		Simultaneous	1.28	.546	.058	-3.40E-02	2.59
LSD	Control	Simultaneous	-.21	.552	.702	-1.32	.89
		Contiguous	-1.49*	.539	.008	-2.57	-.41
	Simultaneous	Control	.21	.552	.702	-.89	1.32
		Contiguous	-1.28*	.546	.023	-2.37	-.19
	Contiguous	Control	1.49*	.539	.008	.41	2.57
		Simultaneous	1.28*	.546	.023	.19	2.37

* The mean difference is significant at the .05 level.

APPENDIX F
PPM CORRELATION BETWEEN PRETEST AND RECALL BY GROUP COMPARISONS

Group			PRETEST	RECALL
Control	PRETEST	Pearson Correlation	1.000	.406
		Sig. (2-tailed)	.	.068
		N	21	21
	RECALL	Pearson Correlation	.406	1.000
		Sig. (2-tailed)	.068	.
		N	21	21
Simultaneous	PRETEST	Pearson Correlation	1.000	.372
		Sig. (2-tailed)	.	.107
		N	20	20
	RECALL	Pearson Correlation	.372	1.000
		Sig. (2-tailed)	.107	.
		N	20	20
Contiguous	PRETEST	Pearson Correlation	1.000	.350
		Sig. (2-tailed)	.	.110
		N	22	22
	RECALL	Pearson Correlation	.350	1.000
		Sig. (2-tailed)	.110	.
		N	22	22

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BIOGRAPHICAL SKETCH

Juwon Park was born in Seoul, South Korea. After receiving a B.A. in philosophy at the Kyung Hee University, he came to the U.S.A. His master's degree is in media studies at the New School University, formerly known as New School for Social Research, and partial courses and projects were completed at the Parsons School of Design. After moving to Gainesville, FL, he has studied the field of educational technology at the School of Teaching and Learning, College of Education, University of Florida. Also, he has worked at various places from a communication company through a college to a K-12 public school.